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EDGEWOOD ARSENAL CONTRACTOR REPORT

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IDENTIFICATION AND EVALUATION OF HAZARDS ASSOCIATED WITH BLENDING OF VIOLET SMOKE MIX BY JET AIRMIX PROCESS

by

Fred L. McIntyre

March 1975

NASA NATIONAL SPACE TECHNOLOGY LABORATORIES
General Electric Company
Engineering and Science Services Laboratory
Bay Saint Louis, Mississippi 39520

Contract No. NAS8-27750

DEPARTMENT OF THE ARMY

Headquarters, Edgewood Arsenal

Aberdeen Proving Ground, Maryland 21010

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A hazards evaluation was conducted to identify and determine the magnitude of hazards in full-scale blending of Violet Smoke Mix IV by the Jet Airmix Process. Sub-scale and full scale blending tests and critical mass and thermal ignition tests were conducted to determine the effects of geometry on sub-scale and full scale tests. Results indicate that hazards associated with mixing Violet Smoke Mix IV are minimal.

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PREFACE

The investigation described in this report was authorized under PEMA 4932, MIPR B4061, Project 5744099, and TWR EA-4D91. It was performed at the NASA National Space Technology Laboratories (NSTL) for the Edgewood Arsenal Resident Laboratory (EARL) and NASA-NSTL by the General Electric Company under Contract No. NAS8-27750. Activity was initiated July 1974 and completed November 1974.

Acknowledgment

Acknowledgments are extended for the technical assistance of C. Pique and General Electric test personnel of the NSTL Keller Road Test Range.

SUMMARY

A hazards evaluation was conducted to identify and determine the magnitude of hazards in full-scale (1000 pounds) blending of Violet Smoke Mix IV, Drawing No. B143-5-1, by the Jet Airmix Process.

The results of this program are summarized as follows:

1. Electrostatic energies generated by triboelectrification were 1.23×10^{-9} joules and 8.04×10^{-2} joules for the bench model and full-scale apparatus, respectively.

2. Hydrodynamic shock of 26.4 psig generated by 7.1 pounds of high explosives and applied to 500 pounds of violet smoke in the operational configuration produces no increase in blast overpressure beyond that of the stimulant charge alone.

3. Thermal ignition of 500 pounds of 1000 pounds of violet smoke mix in both the subscale and full-scale apparatus did not produce observable blast overpressures or result in pneumatic rupture of either vessel.

4. Comparison of Pine Bluff Arsenal conventionally blended smoke mix with the smoke mix blended in the Jet Airmix indicate that a more homogeneous and more even burning material can be achieved by the Jet Airmix process.

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1.0 INTRODUCTION

1.1 Objective. The objective of this study was to generate empirical safety data from tests performed to evaluate the potential hazards associated with full-scale blending of Violet Smoke Mix IV, Drawing No. B143-5-1, in the Jet Airmix blender. * To obtain this objective, four distinct test series were performed:

- Electrostatic investigation to determine the triboelectrification effects and other electrostatic anomalies utilizing both a bench model and full-scale blending equipment.
- Detonation susceptibility investigation (critical mass test) to determine the response of violet smoke mix in the operational configuration to shock initiation.
- Thermal ignition tests whereby 500 and 1000 pounds of violet smoke were initiated by a single heat source which determined the potential for Initiation-Communication-Transition to detonation incident to a mild single "hot spot" initiation in sub-scale and full-scale configurations.
- A determination of homogeneity was made based upon comparison between the Jet Airmix process and the double cone blending method.

The results of these tests may be utilized by cognizant DOD agencies to certify the blending of violet smoke utilizing the Jet Airmix process.

1.2 Authority. The work described in this report was authorized by National Space Technology Laboratories Technical Work Request EA-4D91, dated 19 July 1974.

1.3 Background. The application of the Jet Airmix blender to pyrotechnic composition production is relatively new. An extensive test sequence performed during 1973 resulted in certification to blend HC white smoke mix, and Edgewood Arsenal Manufacturing Technology Directorate has requested that similar certification tests be performed on Violet Smoke Mix IV, Drawing Number B143-5-1, in 1000 pound batch sizes.

Preliminary investigations have revealed that the following hazards are associated with the pneumatic mixing process: surface charge due to triboelectrification, various magnitudes of dust suspension at various concentrations, high impingement velocities of particles and larger batch sized compared to conventional blending. Because of these inherent conditions, the detailed analysis was undertaken to determine the magnitude of these hazards and

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* Trade name of the Sprout-Waldron Company for a unit produced under a patent purchased from Grun, Lissberg, Germany.

whether these hazards are within acceptable limits for full-scale production of violet smoke mix.

2.0 EXPERIMENTAL PROCEDURES

2.1 Sub-Scale Tests

2.1.1 Bench Model Jet Airmix Blender Tests. A series of tests were performed to measure the electrostatic energy generated by pneumatic mixing of violet smoke components. Characteristics of the bench model Jet Airmix blender and experimental arrangements utilizing the Model 610C Keithley electrometer with the 2501 Wilson plate detector probe have been previously described in (EA-FR-4D21, Paragraph 2.3).[1] Two hundred gram quantities of each constituent were preconditioned in an oven at a temperature of 44°C for a minimum of four hours; the samples were then stored in a vacuum desiccator. Each individual ingredient was placed in the bench model mixer, and a blending cycle was instituted that consisted of a two-second pneumatic pulse followed by a 4-second pause, repeated for a total of five times. Each blending cycle was repeated three times at eight detector probe positions to measure the gross generated electrostatic charge. Similar tests were performed utilizing two and three ingredients, and, finally, a full blend composition. Observations of the order of magnitude of electrostatic energies were made.

2.1.2 Thermal Ignition Test. These tests were performed to determine whether mass detonation would occur due to a single heat source initiation. Violet smoke mix was placed in a steel cylinder 22-1/2-inch diameter by 33-1/2-inch height which was approximately 1/2 full-scale geometry of the Jet Airmix blender. The cylinder was capped with a lid that had two 4-inch openings. A 1-gram U.T.C. 3001 propellant* charge was placed at the bottom of the smoke mix and initiated. This test was conducted three times. Observations were made to determine internal static pressures, occurrence of detonation, and burning time. See figure 1 for typical setup.

2.1.3 Burn Rate Comparison Tests. These tests were performed to compare the homogeneity of the Jet Airmix blended materials to those blended by the double cone blender. Measurements of burn rates were determined by placing 7-1/2 pounds of Pine Bluff provided material into a "Vee" shaped trough, 1-7/8 inches high by 3-7/8 inches base and 54 inches in length. The violet smoke was ignited by a match head igniter at one end, then allowed to burn a minimum of six inches (to assure even burning) before measurements were recorded.

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[1] Final Report EA-FR-4D21, Identification and Evaluation of Hazards Associated with Blending of HC White Smoke Mix by Jet Airmix Process, January 1974, F. L. McIntyre.

* United Technology Corporation (UTC) 3001 propellant consisting of ammonium perchlorate, PBAN, and Aluminum.

Figure 1. Thermal Ignition Test Setup

The measurements of distance versus time were made by observing the dropping of filament supported weights at ten-inch intervals and measuring the time with a stop watch. The Jet Airmix blended composition was similarly tested, and the results were compared to bench mark values found in AMCP 706-185[2] and GE-MTSD-R-035[3]. Each test series was performed a minimum of three times. Figure 2 depicts a typical setup.

2.2 Full-Scale Tests

2.2.1 Mass Effects Tests. This test was performed to determine if mass detonation would result from initiation by a shock plane generator. A 500-pound quantity of violet

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[2] Engineering Design Handbook, Military Pyrotechnic Series, Part One, Theory and Application AMCP 706-185, April 1967.

[3] Pyrotechnic Hazards Classification and Evaluation Program, Phase 1, Final Report Constract NAS8-23524, May 1970, D. M. Koger and P. V. King.

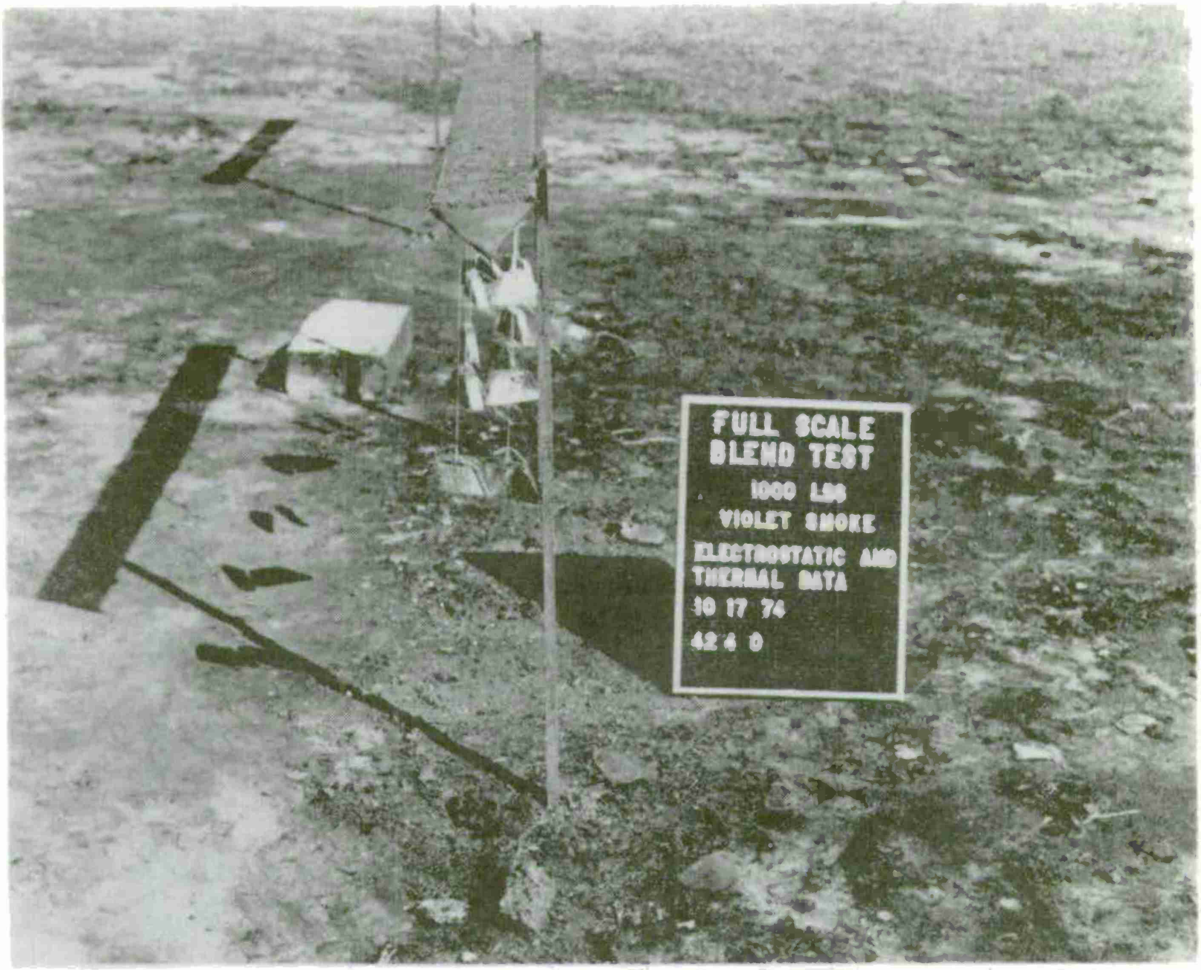


Figure 2. Burn Rate Comparison Test Setup

smoke was encased in a 36-inch diameter by 20-inch, 12-gage steel cylinder. The shock generator consisted of a single coiled layer of 200-grain/foot primacord representing a total of 7.14 pounds of high explosives. Blast instrumentation was deployed to measure side-on blast overpressure contribution due to violet smoke reaction. Velocity probes were located within the material to determine whether reaction velocities corresponded to detonation of the mix. Data from these tests were compared with data from tests performed on inert material (sand) in the same geometry, and determinations were made as to whether:

- There was sufficient shock fron energy to ignite violet smoke,
- Velocities were of sufficient magnitude to indicate detonation, and
- The smoke mix contributed to total blast overpressure.

2.2.2 Full-scale Blend Tests. These tests were performed to determine the order of magnitude of electrostatic charge buildup due to full-scale blending of 1,000 pounds of Violet Smoke Mix IV. Components consisting of 240 pounds of sodium bicarbonate, 90 pounds of sulfur and 420 pounds of violet dye were placed in the Jet Airmix simulator and preblended. The blending cycle consisted of a 2-second pneumatic pulse followed by a 4-second pause repeated five times. Each blending cycle was repeated three times at three predeter-

mined detector probe positions. Upon completion of the pre-blend, 250 pounds of potassium chlorate was added to the mixer, and the blending cycles were repeated at each position similar to the preblend tests. Observations were made to determine the order of magnitude of electrostatic charge, exothermic and endothermic characteristics and if initiation would occur. Figures 3 and 4 depict pneumatic and instrumentation setups.

2.2.3 Full-Scale Thermal Ignition Test. This test was performed to determine if mass detonation or pneumatic rupture of the Jet Airmix blender would occur due to a single heat source initiation. Once the final blend, consisting of 1000 pounds of violet smoke, had been completed, all pneumatic hardware was removed and a single 3-gram charge of U.T.C. 3001 propellant was placed inside the blender near the top of the vee of the cone valve. The propellant was then ignited remotely. Reactions were observed for temperature on the surface of the blender near the initiation source, pneumatic rupture, fire brands, and mass detonation.

2.3 Instrumentation.

2.3.1 Bench Model Jet Airmix Tests. A Keithley Model 610C electrometer with a three-inch Wilson plate static detector probe was attached to the surface of the bench model Jet Airmix blender at two heights in four quadrants. Direct readings were observed to evaluate the electrostatic charge in coulombs. See figure 5 for typical setup and figure 6 for equivalent circuit. Figure 5 does not show the quadrant placement. Report EA-FR-4D21 depicts the actual placement of the quadrant.

2.3.2 Sub-Scale Thermal Ignition Tests. Two chromel/alumel thermocouples were utilized to detect temperature of reaction. One thermocouple was placed at the outlet of one of the four-inch openings. A Dynisco Model PT 182-E1C diaphragm type static pressure transducer was placed inside the vessel to record maximum static pressure generated. Figure 7 depicts the complete setup. The thermocouple and static pressure transducer were coupled to an eight-track magnetic tape recorder for data collection and reduction.

2.3.3 Full-Scale Blending Test. A Keithly Model 610C electrometer with a 2501 Wilson plate static detector probe was placed inside the full-scale mixer simulator at three predetermined locations:

- Near the base of the Laval nozzles for maximum velocity,
- At approximately 1/2 of the column height in the region of the fluidic bed for maximum concentration, and
- One and 1/2 feet from the top for minimum dust concentration levels.

The electrometer was read remotely via closed circuit television and recorded directly on two Bristol strip chart recorders. Two chromel/alumel thermocouples were attached to the outer surface at the base of the cone just above the Laval nozzle outlets. Thermocouples were conditioned in an ice bath reference and red out directly on two Bristol strip chart recorders. Figure 8 shows a typical setup.

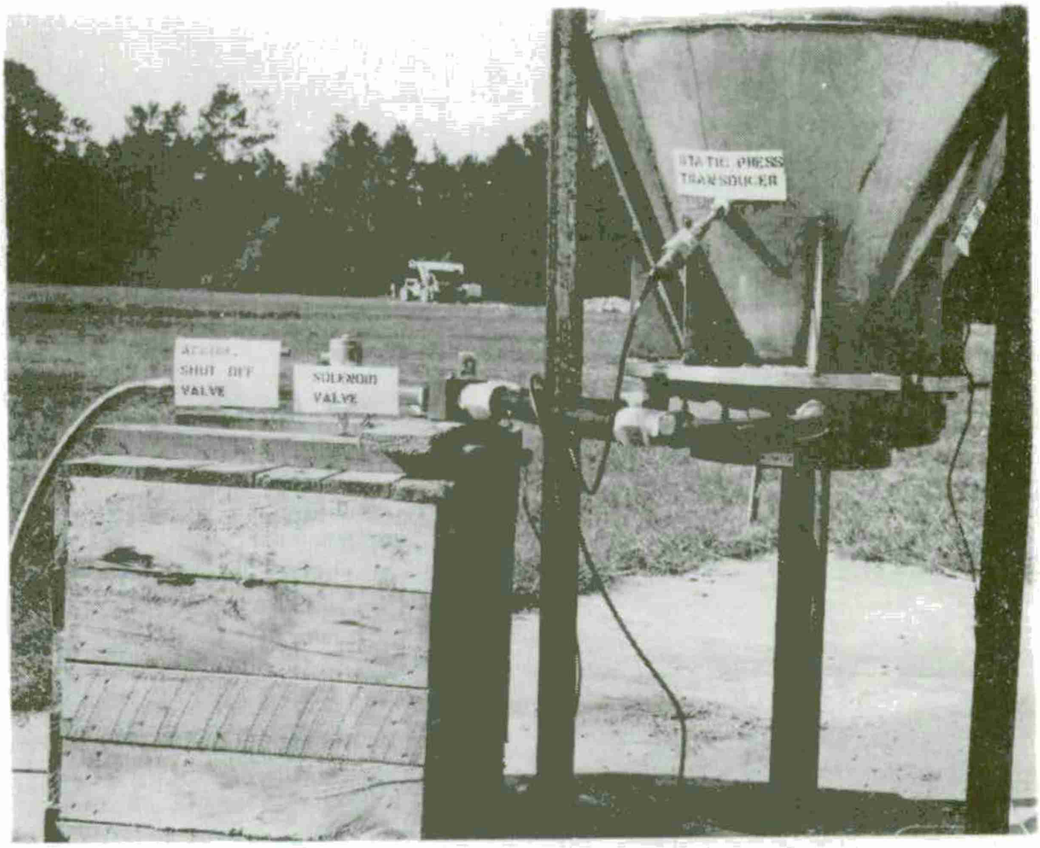


Figure 3. Full-scale Pneumatic Blend Test Setup

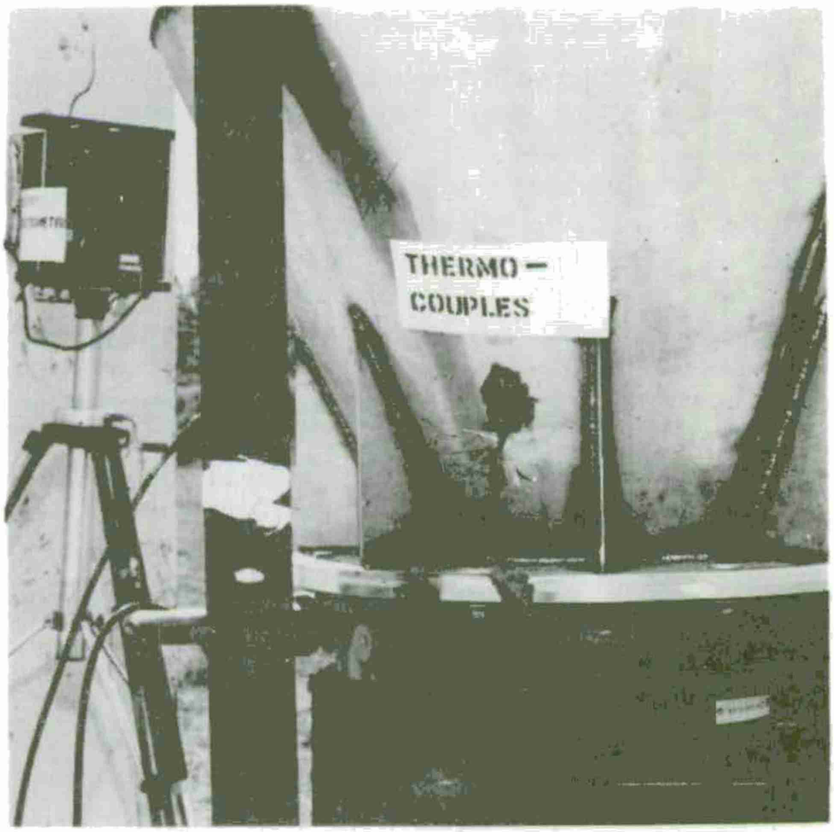


Figure 4. Instrumentation for Full-scale Blend

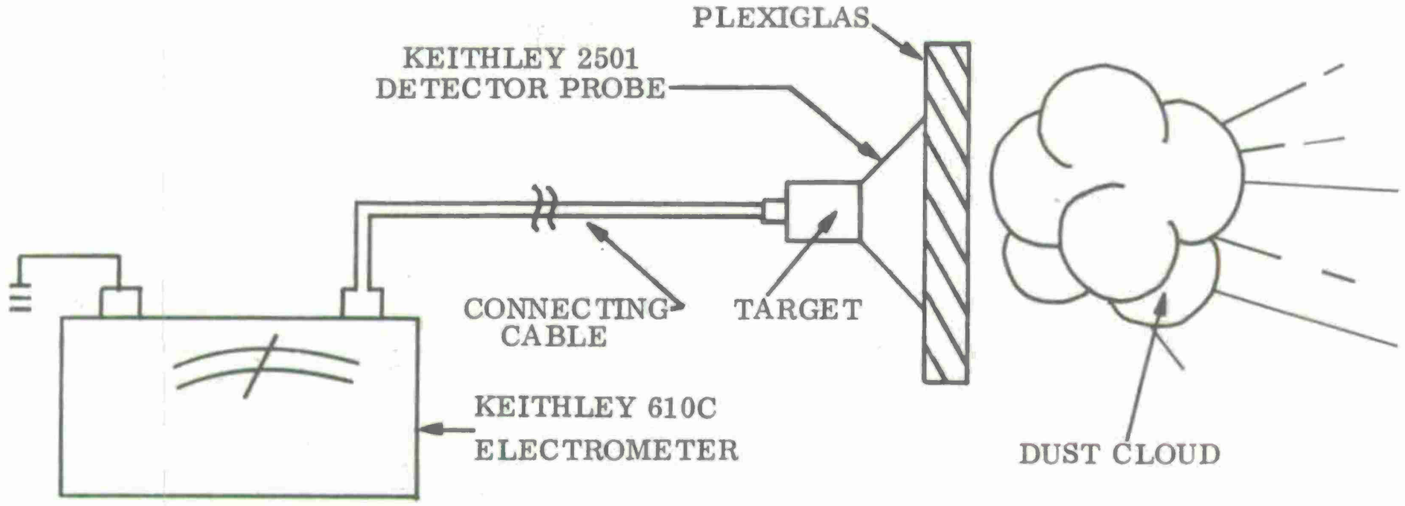


Figure 5. Typical Detector Probe Location

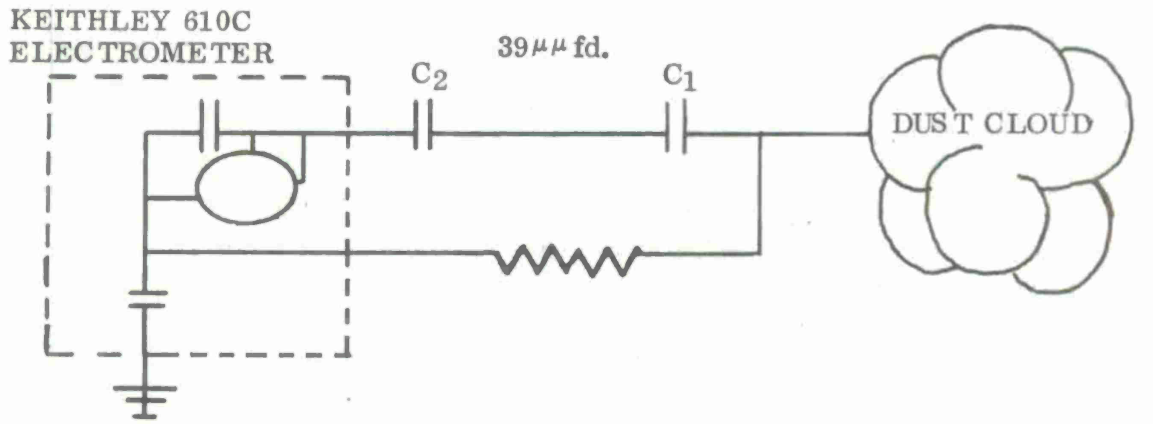


Figure 6. Equivalent Circuit of Airmix Electrometer System

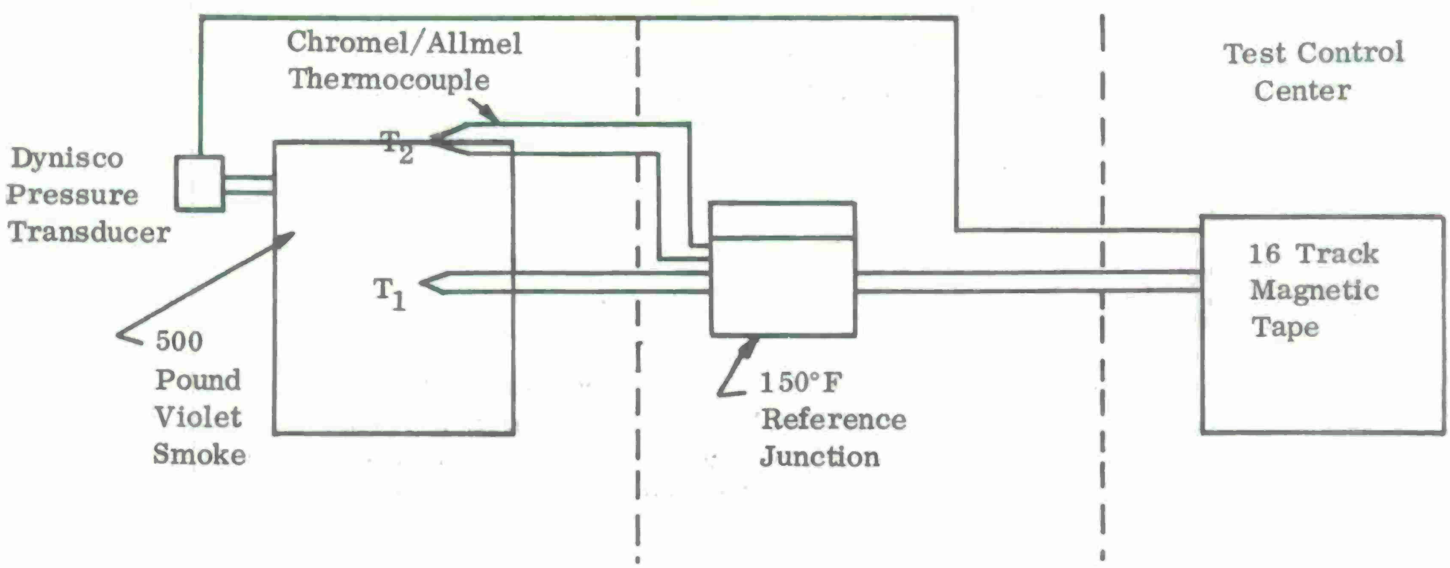


Figure 7. 500-Pound Thermal Ignition Test Depicting Instrumentation Setup

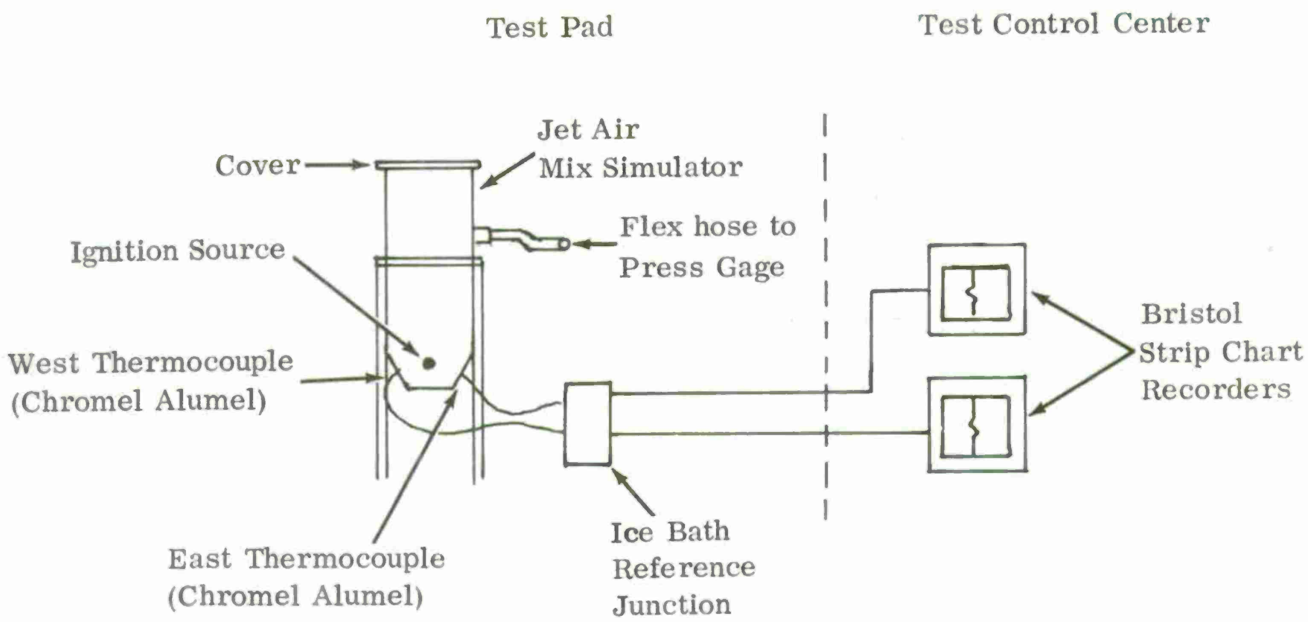


Figure 8. Typical Full-scale Blending Test Setup

2.3.4 Mass Effects Test. The instrumentation utilized for the mass effects tests were: four ST-7 blast transducers with in-line amplifiers coupled to four Model 610C Biomation recorders to measure and record blast overpressure and three carbon resistor velocity probes (developed at NSTL) placed in the violet smoke mix 120° apart 2 inches from the edge of the test vessel. The velocity probes were coupled to an eight-channel electronic counter to record the internal velocities of the shock front within the medium. Before and after still photographs were required as well as 24 pps documentary and 1500 pps high speed motion pictures.

2.3.5 Full-Scale Thermal Ignition Test. Two each chromel/alumel thermocouples were attached at the base on the outside of the cone at two locations 180° apart near the point of initiation source. The thermocouples were coupled to two Bristol strip chart recorders located in the Test Control Center and read directly. Documentary motion picture and still before and after photographs were required.

3.0 RESULTS OF INVESTIGATION

3.1 Test Results

3.1.1 Bench Model Jet Airmix Blender Tests. The purpose of these tests was to determine the most appropriate charging, preblending and discharge sequence for Violet Smoke Mix IV components based upon the order of magnitude of electrostatic energies being generated. Test results utilizing single and multi-constituent mixes are summarized in tables 1-3.

Table 1. Electrostatic Charge Generation Individual Components
(Average Charge Generation of Three Blending Cycles)

Formulation	Total Weight (grams)	Energy Level (Joules) $E = 1/2\ Q^2/C$ *		
		High	Low	Mean
Potassium Chlorate	200	9.33×10^{-7}	7.2×10^{-8}	4.88×10^{-7}
Sulfur	200	1.54×10^{-6}	1.29×10^{-7}	2.83×10^{-7}
Sodium Bicarbonate	200	4.63×10^{-6}	6.30×10^{-8}	4.86×10^{-7}
Violet Dye	200	4.56×10^{-6}	1.15×10^{-7}	2.67×10^{-7}

*See Appendix B for calculation of energy levels.

Table 2. Electrostatic Charge Generation Components Two at a Time
(Average Charge Generation of Three Blending Cycles)

Formulation	Total Weight (grams)	Energy Level (Joules) $E = 1/2\ Q^2/C$*		
		High	Low	Mean
Sodium Bicarbonate/ Sulfur	200	3.52×10^{-7}	6.95×10^{-10}	5.87×10^{-8}
Sodium Bicarbonate/ Potassium Chlorate	200	5.45×10^{-9}	3.64×10^{-10}	5.78×10^{-10}
Sodium Bicarbonate/ Violet Dye	200	1.28×10^{-9}	2.05×10^{-10}	4.37×10^{-10}
Sulfur/Violet Dye	200	1.68×10^{-9}	9.75×10^{-10}	3.17×10^{-10}
Potassium Chlorate/ Violet Dye	200	2.77×10^{-9}	2.05×10^{-10}	4.32×10^{-10}

*See Appendix B for calculation of energy levels.

Table 3. Electrostatic Charge Generation Components Three at a Time and Final Blend
(Average Charge Generation of Three Blending Cycles)

Formulation Sequence	Total Weight (grams)	Energy Level (Joules) $E = 1/2\ {}^{Q^2}/_{C}$ *		
		High	Low	Mean
Sodium Bicarbonate/ Dye/Sulfur	200	1.86×10^{-8}	2.06×10^{-10}	4.14×10^{-10}
Sodium Bicarbonate/ Dye/Potassium Chlorate	200	3.30×10^{-9}	2.06×10^{-10}	3.05×10^{-10}
Sodium Bicarbonate/ Sulfur/Potassium Chlorate	200	2.07×10^{-9}	3.64×10^{-10}	5.51×10^{-10}
**Sodium Bicarbonate/ Sulfur/Dye Potassium Chlorate	200	1.28×10^{-9}	3.64×10^{-10}	5.25×10^{-10}

*See Appendix B for calculation of energy levels.

**Final Blend - Violet Smoke Mix IV Dwg. No. B143-5-1.

3.1.2 Sub-Scale Thermal Ignition Test. The purpose of this test was to determine whether Violet Smoke Mix IV in 500-pound quantities would detonate when a single hot spot initiation source was applied, and whether the gases generated would be sufficient to rupture the test vessel. Test results are shown in table 4.

Table 4. Test Results of Sub-Scale Thermal Ignition Tests

Test Number	Composition Weight (pounds)	Test Results				
		Type Reaction	Max Pressure	Total Burn Rate	Temp. °F 1	Temp. °F 2
33-4-01	500	Burning	6 psig	4 min. 30 sec.	1480	1526
33-4-02	500	Burning	4 psig	6 min. 30 sec.	1765	1806

3.1.3 Burn Rate Comparison Tests. These tests were performed to provide a comparison of blended materials between the Jet Airmix process and conventional methods. Test results are shown in table 5.

3.1.4 Full-Scale Mass Effects Test. The purpose of these tests were to determine whether Violet Smoke Mix IV in 500-pound quantities would detonate when exposed to intense heat and shock. Detonation was defined by peak side-on pressure contribution and velocities exceeding that of sound in the medium. Test results are shown in table 6.

Table 5. Test Results of Burn Rate Comparison Test

Test Number	Test Results		
	Bench Mark* (in./sec.)	Jet Airmix Process (in./sec.)	Conventional** Method (in./sec.)
1	0.07	0.08	0.17
2	0.07	0.07	0.19
3	0.07	0.06	0.16

*Bench Mark data obtained from AMCP 706-185 and GE-MTSD-R035.

**Pine Bluff sample blended August 1974.

Table 6. Mass Effects Test Results

Sample Material	Scaled Distance Z	Expected* Side-on Pres. psig	Recorded Pressure psig	Expected Velocity (ft/sec)	Recorded Velocity (ft/sec)	Mass Detonation
Sand	3.95	59.0	26.6	1100	939	No
Violet Smoke	3.95	59.0	26.4	1100	421	No

*Charge Weight 7.14 lbs.

3.1.5 Full-Scale Blending Tests. The purpose of this test series was to determine those hazards associated with blending a 1000-pound quantity of Violet Smoke Mix IV by measuring surface charges due to triboelectrification. Test results are shown in table 7.

3.1.6 Full-Scale Thermal Ignition Tests. The purpose of this test was to determine whether Violet Smoke Mix IV in a 1000-pound quantity would detonate when a single hot spot initiation source was applied and whether the gases generated would be sufficient to rupture the test vessel. Test results are shown in table 8 and figures 9 and 10.

Table 7. Full-Scale Blending Electrostatic Charge Generation
(Average Charge Generation of Three Blending Cycles)

Formulation	Weight (pounds)	Detector Probe Position	Energy Level (Joules) $E = 1/2\ Q^2/C$ *		
			High	Low	Mean
Preblend	750	1	.131	1.94×10^{-2}	2.41×10^{-2}
		2	1.24×10^{-2}	5.57×10^{-3}	9.54×10^{-3}
		3	1.69×10^{-2}	1.05×10^{-2}	1.43×10^{-2}
Final Blend**	1000	1	8.04×10^{-2}	3.65×10^{-3}	5.63×10^{-3}
		2	8.66×10^{-3}	4.88×10^{-3}	6.98×10^{-3}
		3	1.15×10^{-2}	7.89×10^{-3}	9.44^{-3}

*See Appendix B for calculation of energy levels.

**Violet Smoke Mix IV Dwg. No. B143-5-1.

Table 8. Test Results Full-Scale Thermal Ignition Tests

Test Number	Test Material	Burn Time	Max. Temp.	Max. Internal Pressure
42-4-02	1000 lbs. Violet Smoke	1 min. 50 sec.	$310^{\circ}F$	5 psig

See Appendix A for a chronology of events.

4.0 CONCLUSIONS

Violet Smoke Mix IV, Drawing No. B143-5-1, was subjected to sub- and full-scale tests that employed two distinct initiation sources in three varied geometries and the order of magnitude of electrostatic charge generation was established for the Jet Airmix process. Conclusions from these tests are:

- The orders of magnitude of individual and multi-constituents are comparable to the orders of magnitude found for HC white smoke mix[2] in the sub-scale blending tests.

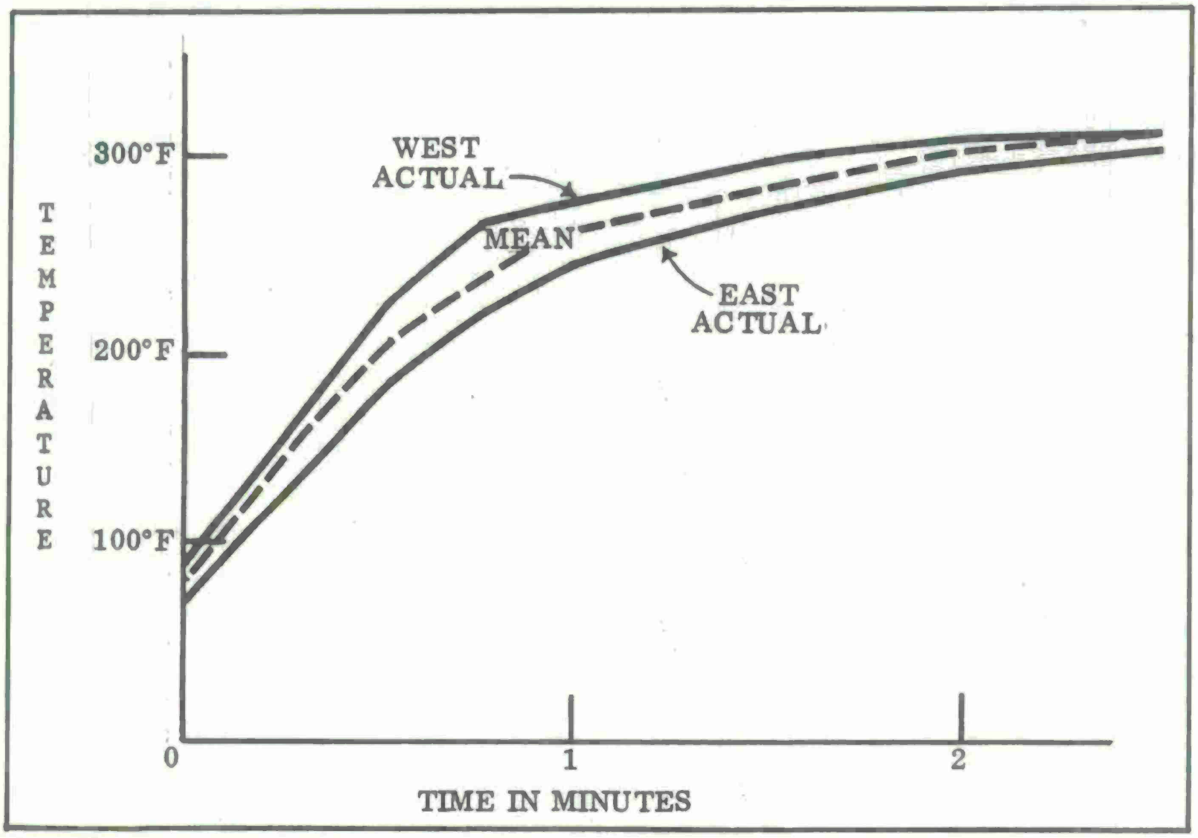


Figure 9. East and West Temperature

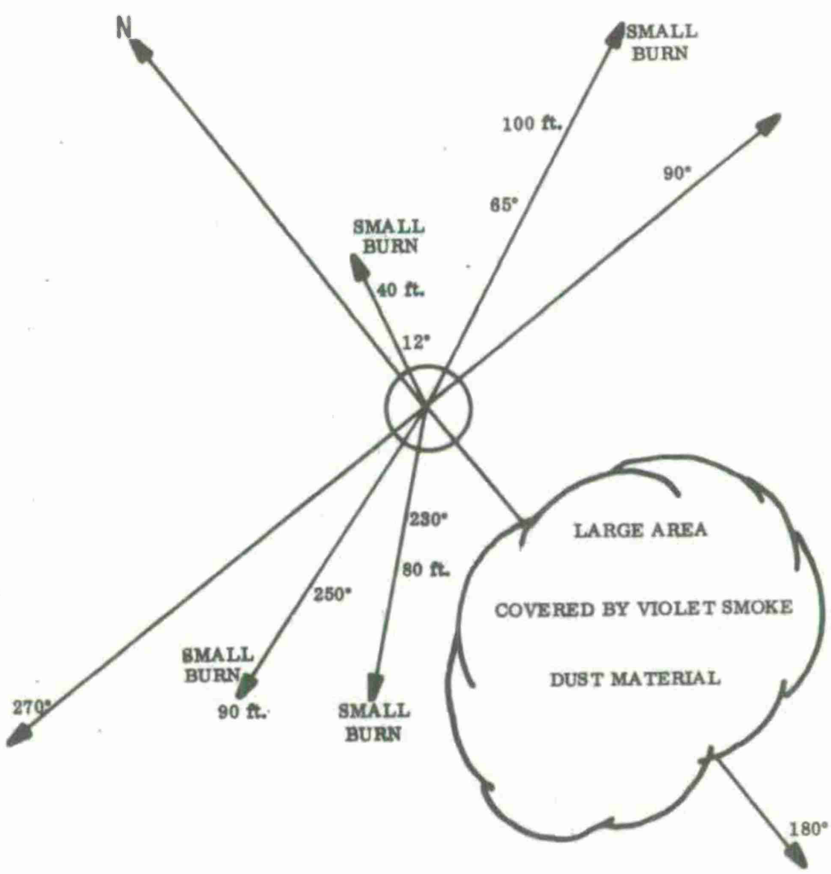


Figure 10. Full-scale Thermal Ignition Blender Test

- The reaction of the sub-scale thermal ignition tests showed no tendency to mass detonate when subjected to a single hot spot initiation source.

- The mass effects tests results indicate that the internal shock front within the medium was attenuated, and there was no contribution from side-on blast pressure to indicate that the 36-inch diameter by 1-1/2 inch high, 500-pound sample of violet smoke mass detonated when subjected to a 7.14-pound high explosive shock plane generator.

- Full-scale thermal ignition test failed to mass detonate when subjected to a single hot spot initiation source in full-scale geometry.

- The orders of magnitude of electrostatic generation in the full-scale blender differed significantly from those measured in the bench model Jet Airmix blender for two specific reasons: (1) equivalent amount composition sizes are approximately 100 orders of magnitude larger for the full-scale blender and (2) the variance of measurement techniques (detector probes) are all significantly different by several orders of magnitude.

The results of this study indicate that minimal risk or hazards are attached to the charging, blending, or discharging by the Jet Airmix process during production of up to 1000 pounds of Violet Smoke Mix IV as formulated per Drawing Number 143-5-1. It shoud be noted that this study was undertaken to evaluate only Violet Smoke Mix IV and that similar conclusions should not be drawn for other compositions in the absence of similar experimental determination.

The full spectrum of potential hazards concerning a complete milling, preconditioning and pneumatic transfer was not within the scope of this study; rather, specific worst case situations were analyzed for Violet Smoke Mix IV.

5.0 RECOMMENDATIONS

Based upon test results and conclusions, the following recommendations with regard to production are made:

- Environmental Factors - No special production environmental controls are warranted as the results of this test series.

- System Ground - The entire processing system should utilize a single-point or common ground with internal resistance of less than 8 ohms.

- Charging/Blending - The mixture should be pre-blended through the addition of either fuel or oxidizer, dilutent, dye, to be followed by a final blend. The charging sequence should not be limited to the method employed in this series.

- Relief Valves - Based upon the results of the thermal ignition test a rupture type diaphragm should be installed to effect control of any inadvertent initiation during the early stages of reaction development; i.e., before transition or communication from deflagration to detonation.

- System Analysis - Studies similar to those reported herein should be performed on other pyrotechnic compositions prior to installation of full-scale production facilities for such formulations.

DATA SUMMARY SHEET

TEST TYPE	INDIVIDUAL CONSTITUENT CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST I-1
LAB CONDITIONS	TEMP 73 °F	HUMIDITY 51 % RH	DATE 05-08-74
MATERIAL	SODIUM BICARBONATE	CHEMICAL FORMULA $NaHCO_3$	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	3.29	6.58	3.07	3.29	3.29	2.19	3.95	3.07	3.60
1-2	0.44	1.32	0.44	0.88	2.19	3.29	0.66	1.97	1.40
1-3	0.44	1.54	0.88	1.76	2.19	1.76	0.66	1.09	1.29
1-4	0.44	0.44	1.32	1.32	1.32	2.19	0.44	0.88	1.05
1-5	1.09	1.09	0.88	1.09	2.19	1.32	0.44	0.66	1.09
2-1	2.19	3.51	2.63	2.85	3.29	2.63	2.63	3.07	2.85
2-2	0.44	1.54	2.19	0.88	1.76	1.32	2.19	1.32	1.45
2-3	0.44	1.76	1.32	1.54	1.54	0.88	0.44	1.76	1.32
2-4	0.44	1.76	1.76	1.76	1.09	0.88	0.44	0.88	1.12
2-5	0.44	2.19	1.97	1.32	1.54	0.88	0.44	0.88	1.21
3-1	2.19	0.88	1.76	2.41	1.76	3.95	3.29	1.76	2.26
3-2	1.09	1.32	2.19	0.88	1.54	1.76	2.19	1.32	1.54
3-3	0.66	0.88	1.32	1.76	1.32	1.09	2.19	1.09	1.32
3-4	0.88	1.32	0.88	2.19	1.32	0.88	2.19	0.88	1.32
3-5	0.66	0.66	0.66	0.88	0.88	0.88	1.76	0.88	0.90

DATA SUMMARY SHEET

TEST TYPE INDIVIDUAL CONSTITUENT CHARGE GENERATION							
TEST APPARATUS BENCH MODEL JET AIRMIX BLENDER						TEST	I-2
LAB CONDITIONS	TEMP 65 °F		HUMIDITY 69 % RH			DATE	09-08-74
MATERIAL SULFUR			CHEMICAL FORMULA		S		
DENSITY: g/cc	PREPARATION		OVEN TEMP 44 °C		TIME	4	HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2							
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	4.39	8.56	3.73	2.63	4.39	6.14	2.19	5.92	4.74
1-2	5.27	4.39	1.09	2.19	3.51	3.51	1.09	4.39	3.18
1-3	3.51	1.54	1.09	1.32	1.76	2.19	0.66	2.63	1.84
1-4	2.19	2.85	1.09	1.09	2.19	2.19	1.54	1.76	1.86
1-5	2.19	2.63	0.44	0.22	3.07	1.76	1.76	1.32	1.76
2-1	4.39	8.12	4.39	7.90	2.85	6.58	2.19	5.05	5.18
2-2	1.76	5.27	1.32	3.51	2.19	3.51	2.19	2.85	2.65
2-3	0.66	1.97	1.76	2.19	1.76	2.63	0.66	2.63	1.78
2-4	2.19	0.88	1.97	4.39	2.19	2.19	0.88	2.19	2.39
2-5	1.32	1.09	0.88	2.19	3.07	1.32	1.32	1.32	1.56
3-1	3.29	3.29	3.07	8.56	2.19	7.24	1.76	2.19	3.97
3-2	0.44	0.44	0.88	4.17	2.19	5.27	1.54	2.19	2.15
3-3	1.76	1.76	1.76	1.76	2.63	3.07	1.32	2.19	2.04
3-4	1.32	1.32	0.44	1.97	3.07	2.19	2.19	1.97	1.82
3-5	1.32	1.32	1.32	2.19	2.19	1.76	2.19	1.54	1.73

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE INDIVIDUAL CONSTITUENT CHARGE GENERATION									
TEST APPARATUS BENCH MODEL JET AIRMIX BLENDER							TEST I-3		
LAB CONDITIONS	TEMP 64 °F			HUMIDITY 58 % RH			DATE 13-08-74		
MATERIAL VIOLET DYE				CHEMICAL FORMULA N/A					
DENSITY: g/cc	PREPARATION		OVEN TEMP 44 °C			TIME 4 HRS			
TEST RESULTS									
TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	6.58	1.32	3.29	1.32	3.29	1.54	2.19	2.19	2.72
1-2	5.48	2.63	1.09	0.88	1.32	2.85	1.32	2.63	2.28
1-3	4.83	1.76	1.09	3.07	0.88	2.63	0.88	2.19	2.17
1-4	3.29	2.41	0.88	2.85	1.32	2.19	0.88	2.41	2.04
1-5	3.07	3.07	0.88	3.29	0.22	3.07	0.88	2.19	2.08
2-1	5.70	2.19	2.19	3.07	2.63	1.54	2.19	3.01	2.83
2-2	2.19	2.41	1.09	3.51	1.09	3.07	1.09	2.19	2.08
2-3	3.73	3.07	1.09	4.39	0.44	2.19	0.88	1.97	2.22
2-4	2.63	5.70	0.88	2.19	0.88	3.07	1.32	2.19	2.37
2-5	1.76	3.51	0.88	3.29	1.76	2.19	0.22	2.19	1.99
3-1	3.07	1.97	1.09	2.19	1.09	2.19	2.19	2.19	1.99
3-2	3.51	2.85	0.88	3.95	1.09	2.19	1.09	1.09	2.08
3-3	1.32	3.07	1.09	4.17	0.88	2.85	0.88	1.76	1.99
3-4	2.19	3.73	2.63	4.39	0.88	2.19	1.09	1.09	2.28
3-5	1.76	3.07	1.09	3.95	0.44	2.63	1.09	1.97	1.73

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	INDIVIDUAL CONSTITUENT CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST I-4
LAB CONDITIONS	TEMP 66 °F	HUMIDITY 59 % RH	DATE 08-08-74
MATERIAL POTASSIUM CHLORATE		CHEMICAL FORMULA $KClO_3$	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.44	0.44	1.09	5.48	4.39	5.49	6.14	0.66	3.03
1-2	0.44	0.88	0.44	6.14	3.29	2.19	2.19	4.17	2.48
1-3	1.09	0.44	0.44	3.29	1.32	1.76	1.53	2.19	1.51
1-4	1.09	1.09	0.44	2.19	1.32	1.09	1.97	1.97	1.40
1-5	1.09	1.09	1.09	1.76	1.76	1.09	1.97	1.09	1.38
2-1	4.39	4.39	3.07	5.48	4.39	5.70	2.19	2.63	4.04
2-2	1.09	3.95	0.44	5.27	2.19	2.63	0.88	1.32	2.22
2-3	1.09	2.19	0.44	3.29	1.09	1.09	3.07	0.66	1.62
2-4	1.09	0.88	1.32	2.19	1.32	1.09	1.32	0.44	1.21
2-5	1.09	0.88	1.32	2.19	2.19	1.09	1.09	0.44	1.29
3-1	3.95	6.58	4.39	3.95	3.29	4.83	2.19	3.07	4.03
3-2	1.32	5.48	0.88	4.39	1.09	2.63	1.53	1.76	2.39
3-3	0.44	3.29	0.88	2.63	2.19	1.32	1.32	0.44	1.56
3-4	1.09	1.09	0.88	2.19	1.54	1.09	1.09	0.44	1.18
3-5	1.76	1.09	1.32	0.88	1.76	0.66	1.09	0.44	1.12

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS TWO AT A TIME CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX		TEST II-1
LAB CONDITIONS	TEMP 60 °F	HUMIDITY 62 % RH	DATE 27-08-74
MATERIAL SODIUM BICARBONATE/DYE		CHEMICAL FORMULA $NaHCO_3$/DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.44	0.44	0.04	0.08	0.11	0.13	0.17	0.17	0.11
1-2	0.39	0.02	0.13	0.04	0.04	0.04	0.08	0.13	0.11
1-3	0.39	0.04	0.13	0.11	0.17	0.04	0.13	0.13	0.15
1-4	0.22	0.02	0.08	0.08	0.08	0.04	0.17	0.08	0.11
1-5	0.04	0.04	0.08	0.04	0.17	0.04	0.08	0.44	0.06
2-1	0.13	0.04	0.13	0.04	0.13	0.04	0.13	0.08	0.08
2-2	0.17	0.04	0.08	0.04	0.13	0.04	0.17	0.13	0.11
2-3	0.13	0.04	0.13	0.04	0.08	0.04	0.04	0.13	0.08
2-4	0.13	0.04	0.04	0.04	0.08	0.04	0.17	0.13	0.08
2-5	0.17	0.04	0.13	0.04	0.13	0.04	0.17	0.11	0.11
3-1	0.13	0.04	0.08	0.04	0.13	0.04	0.08	0.11	0.08
3-2	0.08	0.04	0.08	0.04	0.13	0.04	0.04	0.13	0.08
3-3	0.04	0.04	0.08	0.04	0.08	0.04	0.11	0.13	0.06
3-4	0.08	0.02	0.04	0.04	0.17	0.04	0.13	0.13	0.08
3-5	0.13	0.04	0.04	0.04	0.08	0.08	0.17	0.13	0.08

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS TWO AT A TIME	CHARGE GENERATION	
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST II-2
LAB CONDITIONS	TEMP 62 °F	HUMIDITY 59 % RH	DATE 22-08-74
MATERIAL SODIUM BICARBONATE/SULFUR	CHEMICAL FORMULA $NaHCO_3 + S$		
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	3.07	2.19	3.07	3.07	3.07	2.19	3.07	0.13	2.48
1-2	0.17	0.08	0.17	0.08	0.17	0.13	0.17	0.04	0.13
1-3	2.63	0.06	0.17	0.06	0.13	0.11	2.19	0.04	0.68
1-4	0.17	0.04	0.19	0.06	0.17	0.04	0.17	0.08	0.13
1-5	0.17	0.04	0.13	0.04	0.17	0.06	0.17	0.08	0.11
2-1	0.17	0.06	0.13	0.06	0.17	0.08	0.13	0.04	0.11
2-2	0.17	0.06	0.13	0.04	0.17	0.04	0.17	0.08	0.11
2-3	0.13	0.04	0.11	0.06	0.17	0.04	0.17	0.08	0.11
2-4	2.19	0.04	0.17	0.08	0.11	0.06	0.13	0.08	0.15
2-5	2.19	0.08	0.15	2.63	0.17	0.06	0.13	0.02	0.68
3-1	0.17	0.02	0.13	0.08	0.17	0.04	0.17	0.08	0.11
3-2	0.17	0.04	0.13	0.04	0.13	0.04	0.17	0.04	0.11
3-3	2.19	0.08	0.13	0.04	0.17	0.04	0.17	0.04	0.37
3-4	2.63	0.04	0.17	0.04	0.13	0.02	0.17	0.02	0.42
3-5	2.19	0.04	0.13	0.04	0.17	0.06	0.19	0.04	0.37

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS TWO AT A TIME	CHARGE GENERATION	
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST II-3
LAB CONDITIONS	TEMP 64 °F	HUMIDITY 61 % RH	DATE 23-08-74
MATERIAL	SODIUM BICARBONATE/ POTASSIUM CHLORATE	CHEMICAL FORMULA $NaHCO_3 + KClO_3$	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.39	0.26	0.26	0.37	0.13	0.35	0.22	0.53	0.31
1-2	0.22	0.13	0.17	0.13	0.08	0.17	0.13	0.22	0.15
1-3	0.17	0.08	0.13	0.13	0.13	0.17	0.11	0.04	0.13
1-4	0.17	0.04	0.13	0.11	0.06	0.11	0.13	0.08	0.11
1-5	0.13	0.06	0.13	0.08	0.08	0.11	0.13	0.04	0.11
2-1	0.13	0.06	0.13	0.08	0.08	0.13	0.11	0.08	0.11
2-2	0.13	0.06	0.13	0.06	0.04	0.08	0.13	0.08	0.08
2-3	0.13	0.04	0.13	0.06	0.04	0.08	0.13	0.13	0.11
2-4	0.17	0.06	0.13	0.06	0.08	0.08	0.13	0.08	0.11
2-5	0.22	0.04	0.08	0.06	0.08	0.04	0.08	0.13	0.08
3-1	0.13	0.06	0.13	0.06	0.04	0.11	0.17	0.08	0.11
3-2	0.17	0.06	0.17	0.08	0.06	0.06	0.17	0.08	0.11
3-3	0.17	0.06	0.13	0.04	0.04	0.06	0.17	0.08	0.11
3-4	0.13	0.06	0.08	0.04	0.06	0.04	0.13	0.08	0.08
3-5	0.13	0.04	0.13	0.06	0.06	0.04	0.13	0.04	0.08

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS TWO AT A TIME CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST II-4
LAB CONDITIONS	TEMP 62 °F	HUMIDITY 60 % RH	DATE 27-08-74
MATERIAL SULFUR/DYE		CHEMICAL FORMULA S + DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.11	0.08	0.13	0.35	0.44	0.08	0.22	0.04	0.17
1-2	0.39	0.08	0.08	0.17	0.13	0.17	0.57	0.08	0.22
1-3	0.39	0.08	0.04	0.17	0.13	0.08	0.17	0.08	0.15
1-4	0.44	0.08	0.04	0.22	0.19	0.13	0.26	0.04	0.17
1-5	0.57	0.08	0.04	0.22	0.06	0.08	0.22	0.08	0.17
2-1	0.44	0.15	0.08	0.08	0.06	0.13	0.13	0.06	0.15
2-2	0.35	0.13	0.04	0.17	0.13	0.04	0.13	0.11	0.13
2-3	0.39	0.15	0.08	0.13	0.08	0.13	0.08	0.06	0.15
2-4	0.48	0.13	0.08	0.13	0.08	0.06	0.08	0.08	0.15
2-5	0.39	0.17	0.08	0.15	0.13	0.11	0.13	0.08	0.17
3-1	0.44	0.08	0.08	0.08	0.11	0.17	0.08	0.13	0.15
3-2	0.39	0.15	0.08	0.17	0.08	0.04	0.13	0.08	0.15
3-3	0.44	0.13	0.04	0.08	0.04	0.13	0.13	0.08	0.13
3-4	0.48	0.13	0.04	0.08	0.08	0.13	0.08	0.13	0.15
3-5	0.53	0.08	0.08	0.08	0.08	0.08	0.04	0.11	0.13

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS TWO AT A TIME CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST II-5
LAB CONDITIONS	TEMP 62 °F	HUMIDITY 64 % RH	DATE 28-08-74
MATERIAL POTASSIUM CHLORATE/DYE		CHEMICAL FORMULA $KClO_3$ + DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.44	0.11	0.26	0.08	0.53	0.08	0.04	0.22	0.22
1-2	0.08	0.04	0.13	0.06	0.19	0.04	0.04	0.17	0.11
1-3	0.13	0.11	0.11	0.04	0.08	0.02	0.02	0.08	0.08
1-4	0.04	0.11	0.17	0.04	0.22	0.02	0.44	0.11	0.13
1-5	0.04	0.11	0.22	0.06	0.02	0.06	0.06	0.08	0.08
2-1	0.04	0.04	0.13	0.06	0.13	0.04	0.04	0.08	0.06
2-2	0.08	0.08	0.15	0.02	0.02	0.04	0.04	0.17	0.08
2-3	0.11	0.06	0.13	0.04	0.13	0.02	0.06	0.06	0.08
2-4	0.06	0.06	0.17	0.02	0.17	0.04	0.04	0.06	0.08
2-5	0.02	0.08	0.11	0.02	0.17	0.04	0.04	0.11	0.08
3-1	0.17	0.04	0.22	0.06	0.02	0.02	0.02	0.13	0.08
3-2	0.13	0.08	0.11	0.06	0.17	0.04	0.02	0.13	0.08
3-3	0.15	0.06	0.26	0.08	0.13	0.04	0.02	0.11	0.11
3-4	0.15	0.04	0.26	0.04	0.02	0.02	0.02	0.06	0.08
3-5	0.15	0.08	0.19	0.02	0.15	0.04	0.04	0.06	0.08

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS THREE AT A TIME CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST III-1
LAB CONDITIONS	TEMP 63 °F	HUMIDITY 59 % RH	DATE 28-08-74
MATERIAL POTASSIUM CHLORATE + DYE + SODIUM BICARBONATE		CHEMICAL FORMULA $KClO_3 + NaHCO_3$ + DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP °C	TIME HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.04	0.33	0.33	0.26	0.66	0.04	0.04	0.22	0.24
1-2	0.13	0.13	0.08	0.08	0.17	0.66	0.04	0.04	0.17
1-3	0.17	0.06	0.13	0.04	0.17	0.08	0.11	0.04	0.11
1-4	0.17	0.08	0.15	0.04	0.08	0.11	0.06	0.04	0.11
1-5	0.13	0.04	0.08	0.02	0.11	0.04	0.06	0.08	0.06
2-1	0.13	0.06	0.11	0.04	0.17	0.08	0.04	0.04	0.08
2-2	0.13	0.06	0.02	0.04	0.15	0.13	0.02	0.04	0.08
2-3	0.17	0.06	0.04	0.04	0.04	0.11	0.08	0.04	0.08
2-4	0.13	0.11	0.04	0.06	0.06	0.13	0.13	0.08	0.08
2-5	0.13	0.06	0.04	0.04	0.04	0.08	0.06	0.04	0.06
3-1	0.13	0.04	0.02	0.04	0.11	0.06	0.06	0.06	0.06
3-2	0.17	0.04	0.06	0.04	0.04	0.08	0.08	0.06	0.08
3-3	0.22	0.04	0.06	0.06	0.06	0.13	0.06	0.04	0.08
3-4	0.13	0.06	0.06	0.08	0.06	0.06	0.06	0.06	0.08
3-5	0.11	0.04	0.02	0.06	0.06	0.06	0.11	0.04	0.06

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS THREE AT A TIME	CHARGE GENERATION	
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST III-2
LAB CONDITIONS	TEMP 60 °F	HUMIDITY 60 % RH	DATE 30-08-74
MATERIAL SULFUR + DYE + SODIUM BICARBONATE		CHEMICAL FORMULA $S + NaHCO_3$ + DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.92	0.53	0.59	0.53	0.55	0.11	0.97	0.37	0.57
1-2	0.26	0.26	0.04	0.19	0.22	0.04	0.06	0.17	0.15
1-3	0.19	0.22	0.02	0.06	0.22	0.04	0.02	0.13	0.11
1-4	0.29	0.15	0.04	0.04	0.17	0.04	0.04	0.08	0.11
1-5	0.22	0.04	0.04	0.04	0.04	0.04	0.02	0.15	0.08
2-1	0.22	0.17	0.11	0.04	0.11	0.02	0.02	0.11	0.11
2-2	0.17	0.04	0.11	0.04	0.08	0.02	0.06	0.17	0.08
2-3	0.04	0.15	0.08	0.04	0.06	0.02	0.08	0.08	0.06
2-4	0.04	0.11	0.06	0.06	0.06	0.08	0.04	0.11	0.06
2-5	0.44	0.08	0.11	0.06	0.06	0.02	0.08	0.13	0.13
3-1	0.08	0.02	0.08	0.08	0.08	0.13	0.04	0.02	0.06
3-2	0.04	0.04	0.08	0.04	0.08	0.11	0.11	0.08	0.08
3-3	0.04	0.04	0.04	0.06	0.06	0.02	0.11	0.11	0.06
3-4	0.22	0.04	0.06	0.13	0.08	0.06	0.11	0.06	0.11
3-5	0.04	0.04	0.04	0.06	0.04	0.08	0.08	0.06	0.06

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	CONSTITUENTS THREE AT A TIME CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST III-3
LAB CONDITIONS	TEMP 60 °F	HUMIDITY 62 % RH	DATE 03-09-74
MATERIAL	POTASSIUM CHLORATE + SULFUR + SODIUM BICARBONATE	CHEMICAL FORMULA $KClO_3 + S + NaHCO_3$	
DENSITY: g/cc	PREPARATION	OVEN TEMP 44 °C	TIME 4 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.26	0.26	0.22	0.11	0.19	0.08	0.19	0.17	0.19
1-2	0.04	0.02	0.11	0.13	0.13	0.04	0.06	0.11	0.08
1-3	0.11	0.04	0.11	0.17	0.11	0.04	0.06	0.06	0.08
1-4	0.11	0.04	0.11	0.15	0.11	0.11	0.08	0.06	0.11
1-5	0.08	0.04	0.08	0.19	0.11	0.08	0.06	0.08	0.08
2-1	0.06	0.06	0.08	0.15	0.13	0.13	0.06	0.06	0.08
2-2	0.06	0.02	0.11	0.15	0.08	0.06	0.08	0.08	0.08
2-3	0.06	0.04	0.06	0.17	0.11	0.26	0.06	0.04	0.11
2-4	0.02	0.02	0.06	0.17	0.11	0.11	0.11	0.04	0.08
2-5	0.02	0.04	0.06	0.15	0.15	0.22	0.22	0.04	0.11
3-1	0.04	0.06	0.04	0.13	0.17	0.22	0.13	0.06	0.11
3-2	0.06	0.06	0.08	0.22	0.17	0.17	0.19	0.04	0.13
3-3	0.06	0.08	0.11	0.15	0.29	0.22	0.19	0.04	0.13
3-4	0.13	0.08	0.13	0.13	0.22	0.11	0.15	0.02	0.13
3-5	0.19	0.11	0.17	0.17	0.29	0.19	0.19	0.02	0.17

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	FINAL BLEND CHARGE GENERATION		
TEST APPARATUS	BENCH MODEL JET AIRMIX BLENDER		TEST IV-1
LAB CONDITIONS	TEMP 67 °F	HUMIDITY 67 % RH	DATE 05-09-74
MATERIAL	SODIUM BICARBONATE + DYE + SULFUR/POTASSIUM CHLORATE	CHEMICAL FORMULA	$NaHCO_3$ + S + DYE + $KClO_3$
DENSITY: g/cc	PREPARATION	OVEN TEMP 4 °C	TIME 44 HRS

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-12} coulombs/cm^2								
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	Avg.
1-1	0.31	0.04	0.26	0.13	0.08	0.02	0.11	0.17	0.15
1-2	0.17	0.06	0.26	0.06	0.11	0.06	0.06	0.13	0.11
1-3	0.13	0.08	0.13	0.04	0.13	0.06	0.04	0.08	0.08
1-4	0.17	0.04	0.17	0.04	0.13	0.08	0.11	0.13	0.11
1-5	0.13	0.08	0.08	0.04	0.15	0.11	0.08	0.11	0.11
2-1	0.15	0.08	0.13	0.06	0.15	0.08	0.08	0.11	0.11
2-2	0.15	0.08	0.08	0.08	0.15	0.06	0.06	0.13	0.11
2-3	0.19	0.06	0.08	0.11	0.11	0.06	0.06	0.15	0.11
2-4	0.15	0.04	0.04	0.06	0.13	0.06	0.04	0.13	0.08
2-5	0.26	0.06	0.06	0.11	0.11	0.06	0.04	0.15	0.11
3-1	0.13	0.13	0.04	0.08	0.11	0.08	0.06	0.08	0.08
3-2	0.22	0.06	0.06	0.06	0.13	0.08	0.08	0.11	0.11
3-3	0.19	0.04	0.02	0.11	0.08	0.08	0.08	0.04	0.08
3-4	0.17	0.06	0.06	0.08	0.15	0.06	0.04	0.06	0.08
3-5	0.13	0.02	0.06	0.08	0.13	0.04	0.06	0.06	0.08

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	FULL SCALE BLENDING (PRE-BLEND)		
TEST APPARATUS	FULL SCALE JET AIRMIX SIUMLATOR		TEST
LAB CONDITIONS	TEMP °F	HUMIDITY % RH	DATE
MATERIAL SODIUM BICARBONATE + SULFUR + DYE		CHEMICAL FORMULA $NaHCO_3$ + S + DYE	
DENSITY: g/cc	PREPARATION	OVEN TEMP N/A °C	TIME N/A HRS

TEST RESULTS

TEST#/CYCLE	P_1	P_2	P_3	Avg.					
1-1	3.94	11.81	2.68	6.14					
1-2	3.94	3.44	1.57	3.15					
1-3	3.94	3.94	1.18	2.99					
1-4	3.94	2.36	0.79	2.36					
1-5	3.94	2.36	1.10	2.52					
2-1	2.68	0.16	0.79	1.26					
2-2	3.62	0.79	1.18	1.89					
2-3	3.31	0.79	1.57	1.89					
2-4	3.31	0.16	1.18	1.57					
2-5	3.54	0.24	1.57	1.57					
3-1	4.09	0.16	1.57	1.97					
3-2	4.17	0.24	0.79	1.73					
3-3	4.09	0.55	1.18	1.97					
3-4	4.09	0.55	2.13	2.20					
3-5	4.17	0.79	1.81	2.20					

APPENDIX A

DATA SUMMARY SHEET

TEST TYPE	FULL SCALE BLENDING (FINAL BLEND)			
TEST APPARATUS	FULL SCALE JET AIRMIX SIMULATOR			TEST
LAB CONDITIONS	TEMP °F	HUMIDITY % RH		DATE
MATERIAL	SODIUM BICARBONATE + SULFUR POTASSIUM CHLORATE + DYE	CHEMICAL FORMULA	$KC10_3$ + S + DYE $NaHCO_3$	
DENSITY: g/cc	PREPARATION	OVEN TEMP N/A °C	TIME N/A HRS	

TEST RESULTS

TEST#/CYCLE	Charge Density = σ = Q/A = 10^{-11} coulombs/cm^2								
	P_1	P_2	P_3	Avg.					
1-1	0.79	0.79	1.57	1.02					
1-2	0.94	0.94	1.42	1.10					
1-3	1.02	0.94	1.02	1.02					
1-4	11.81	1.18	0.94	4.65					
1-5	11.81	1.34	1.18	4.80					
2-1	1.26	1.18	1.18	1.18					
2-2	1.42	1.26	1.34	1.34					
2-3	1.50	1.10	1.42	1.34					
2-4	1.73	1.50	1.50	1.57					
2-5	1.97	1.42	1.42	1.57					
3-1	2.36	0.94	1.42	1.57					
3-2	1.97	1.26	1.26	1.50					
3-3	1.97	1.26	1.57	1.57					
3-4	2.36	1.26	1.73	1.81					
3-5	2.36	1.34	1.57	1.73					

APPENDIX A

BLAST MEASUREMENT DATA

TEST TYPE	Shock Plane Generator Calibration Test							
PRE CAL#	37-4-81	POST CAL#		TEST#	37-4-02			
TEST WT.	500 Pounds			DATE	9/13/74			
CONFIGURATION	Sand Blaster's Sand 36" x 10" 7.14 lbs. HE Shock Plane Generator			TIME	1300			
DATA CHN.	1	2	3	4	5	6	7	8
DISTANCE "R"	7.6	7.6	7.6	7.6				
SCALED DIST. (Z)	3.95	3.95	3.95	3.95				
PRE CAL — PRESSURE (psig)	100	100	100	100				
PRE CAL — VOLTS F.S.	2	2	2	2				
PRE CAL — UNITS F.S.	49	31	21	35				
POST CAL — PRESSURE (psig)								
POST CAL — VOLTS F.S.								
POST CAL — UNITS F.S.								
RECOR SET — VOLTS F.S.	2	2	5	2				
RECOR SET — RATE μSEC	10	10	10	20				
TEST DATA — E. O. R. msec	4852	5408	-	4981				
TEST DATA — UNITS	14	7	-	10				
TEST DATA — PK. PRESS	28.6	22.6		28.6				

APPENDIX A

INIT. TO BW msec

Instrumentation Signature

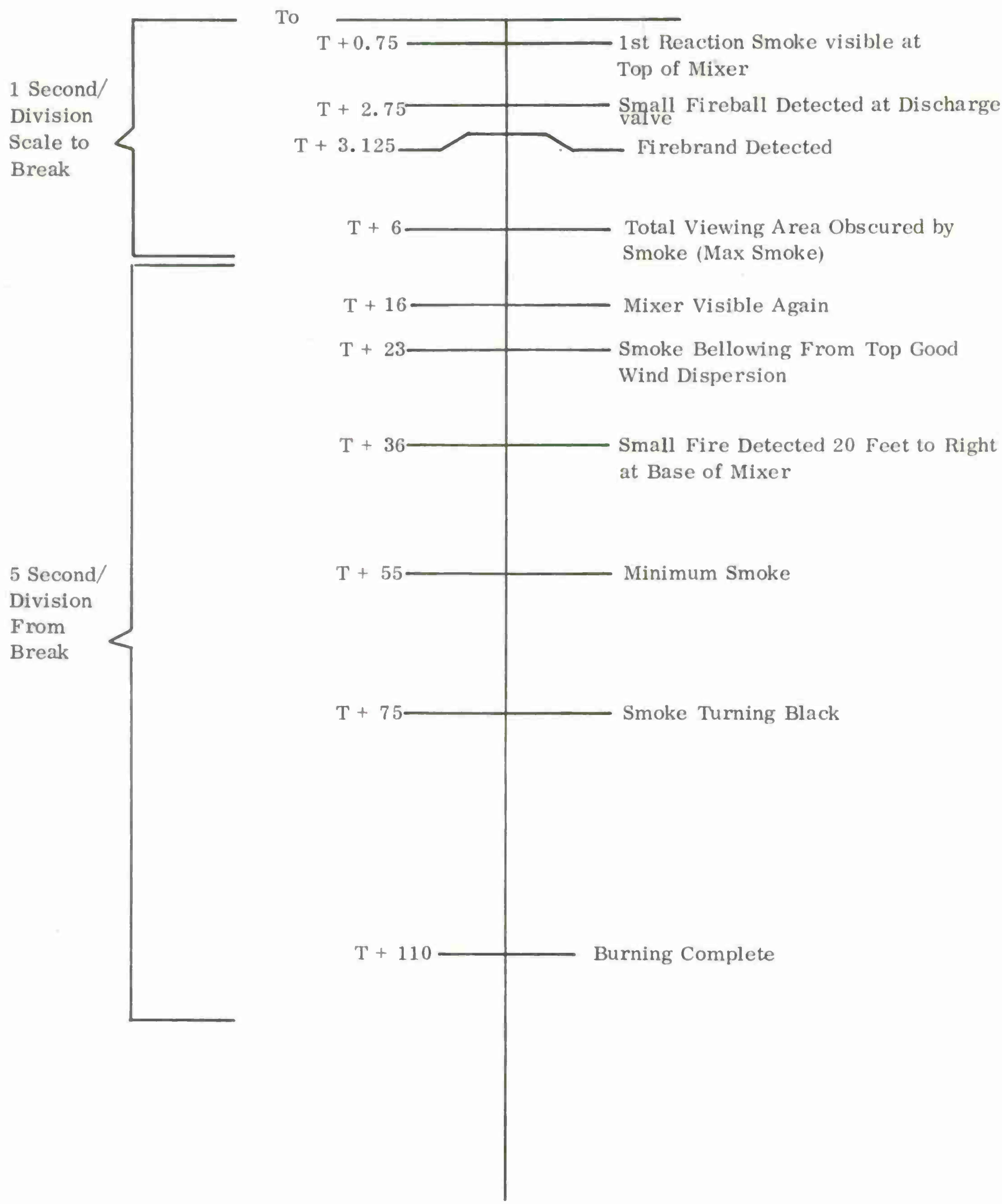
BLAST MEASUREMENT DATA

TEST TYPE	Mass Effects Test (Violet Smoke)							
PRE CAL#	37-4-81	POST CAL#				TEST#		
TEST WT.	500 Pounds					DATE		
CONFIGURATION	500 lbs. Violet Smoke 36" x 11-1/2" Steel Cylinder 7.14 HE Shock Plane Generator					TIME		
DATA CHN.	1	2	3	4	5	6	7	8
DISTANCE "R"	7.6	7.6	7.6	7.6				
SCALED DIST. (Z)	3.95	3.95	3.95	3.95				
PRE CAL — PRESSURE (psig)	100	100	100	100				
PRE CAL — VOLTS F.S.	2	2	5	2				
PRE CAL — UNITS F.S.	49	31	21	35				
POST CAL — PRESSURE (psig)								
POST CAL — VOLTS F.S.								
POST CAL — UNITS F.S.								
RECOR SET — VOLTS F.S.	2	2	5	2				
RECOR SET — RATE μSEC	10	10	10	20				
TEST DATA — E. O. R. msec	2.923	2.920	3.578	2.845				
TEST DATA — UNITS	12	8	5	11				
TEST DATA — PK. PRESS	24.5	25.8	23.8	31.4				

APPENDIX A

INIT. TO BW msec

Instrumentation Signature



Chronology of Events
Full Scale Thermal Ignition Test

APPENDIX B — CALCULATIONS

JET AIRMIX BLENDER ELECTROSTATIC ENERGY CALCULATIONS

(Full-Scale Production Model)

The calculations are to scale up from the bench model to the full-scale production model. The full-scale Jet Airmix represents a solid cylindrical capacitor 114-1/4 inches in length by 36 inches in diameter with an overall maximum surface charge density of $.84 \times 10^{-12}$ coulombs/cm^2 (see data summary sheet CH mix). Therefore, the total electrostatic charge generated within the mixing vessel is:

$$Q = \sigma \pi \, dl$$

where Q = electrostatic charge in coulombs

σ = charge density in coulombs/cm^2

l = length of cylinder in centimeters

d = diameter of cylinder in centimeters

π = 3.14

substituting:

$$Q = 3.14 \times 2.9 \times 10^2 \times 91.44 \times 1.57 \times 10^{-11}$$

$$Q = 1.31 \times 10^{-6}$$

The capacitance of a solid cylinder of radius "a" and length "l" is given by:

$$C = (8 + 6.95 \; ({}^{1}/2a)^{3/4}) \; (Ea)$$

where C = capacitance in farads

l = length of cylinder in meters

a = radius of cylinder in meters

E = permitivity = $E_1 \times E = 8.85 \times 10^{-12}$ farad/meter

substituting:

$$C = (8 + 6.95 \; (\frac{2.9}{.9})) \quad (8.85 \times 10^{-12} \times .457)$$

$$C = (8 + 6.95 \times 2.38) \quad (8.85 \times 10^{-12} \times .457)$$

$$C = 0.99 \times 10^{-10} \text{ farad}$$

Finally, the equivalent energy of a charged capacitor may be calculated by the following expression:

$$E = \frac{Q^2}{2C}$$

where E = energy expressed in joules

Q = electrostatic charge in coulombs

C = capacitance in farads

substituting:

$$E = 1/2 \frac{(1.31 \times 10^{-6})^2}{.99 \times 10^{-10}}$$

$$E = 8.66 \times 10^{-3} \text{ Joules}$$

All calculations are based upon an ungrounded system that would not be found in use during production, and therefore these calculations constitute the worst case condition. Charge densities would be lower thus effectively reducing the amount of energy being generated during the charging, blending and discharge cycles if grounding was provided.

JET AIRMIX BLENDER ELECTROSTATIC ENERGY CALCULATIONS

(Scale Mixer)

The mixing container, for the purposes of this analysis, represents a solid cylindrical capacitor 11-7/8 inches long by 4-3/4 inches in diameter with a maximum overall surface charge density 1.05×10^{-12} coulombs/cm^2 (see data sheet summary sodium bicarbonate). Therefore, the total electrostatic charge generated within the mixing vessel is charge:

$$Q = \pi \, d \, l \, \sigma$$

where: σ = charge density in coul/cm^2

l = length of the cylinder in centimeters

d = diameter of the cylinder in centimeters

π = 3.14

Q = electrostatic charge in coulombs

$$Q = 3.14 \times 30.1625 \times 12.065 \times 1.05 \times 10^{-12}$$

$$Q = 1.20 \times 10^{-9} \text{ coulombs}$$

Similarly, the capacitance of a solid cylinder of a radius of "a" and length " ℓ " is given by:

$$C = (8 + 6.95 \, (\ell /2a)^{.75} \, Ea.$$

where: permitivity, $E_x = E_1 \, X \, E_o = 8.85 \, X \, 10^{-12}$ farad/meter

$$C = (8 + 6.95 \, (\frac{30.165}{12.065})^{3/4} \,) \, (8.85 \, X \, 10^{-12} \, X \, .06)$$

$$C = 11.4 \, X \, 10^{-12} \text{ farads}$$

Finally, the equivalent energy of a charge capacitor may be calculated by the following expressions:

$$E = \frac{Q^2}{2C}$$

where: E = energy expressed in joules

Q = electrostatic charge in coulombs

C = capacitance in farads

$$E = 1/2 \; \frac{(1.20\times10^{-9})^2}{11.4 \times 10^{-12} \text{ farad}} = 6.30\times10^{-8}$$

$E = 6.30\times10^{-8}$ Joules

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